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Hand Dismantling and Shredding of Japanese Automobiles To Determine Material Contents and Metal Recoveries

By J. W. Sterner, D. K. Steele, and M. B. Shirts



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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

| | | | |
|-----------------|------------------|-----|---------|
| °C | degree Celsius | lb | pound |
| cm ³ | cubic centimeter | min | minute |
| in | inch | pct | percent |

HAND DISMANTLING AND SHREDDING OF JAPANESE AUTOMOBILES TO DETERMINE MATERIAL CONTENTS AND METAL RECOVERIES

By J. W. Sterner,¹ D. K. Steele,² and M. B. Shirts³

ABSTRACT

The Bureau of Mines conducted studies on four makes of Japanese automobiles, three 1981 and one 1982 model years, received from three manufacturers to determine if their materials composition would present problems to the current technology used to process junk automobiles for metal recovery. One of each make of automobile was hand-dismantled to determine the materials composition. In addition, two nearly identical automobiles of each make were shredded at a commercial operation where all metal products and rejects were collected for analysis to determine metal and nonmetal distribution. The average weight of the four automobiles to be dismantled, less batteries, tools, and fluids, was 1,938.3 lb. The weight was distributed as 1,472.9 lb ferrous and 115.6 lb nonferrous metals, 275.2 lb combustibles, 72.3 lb noncombustibles, and 2.3 lb electrical components. The dismantled automobiles, less gas tanks, fluids, tools, wheels, tires, and batteries, which were all removed from the automobiles that were shredded, contained an average of 1,389.1 lb ferrous and 101.6 lb nonferrous metals, 305.7 lb nonmetals, and 2.3 lb electrical components. In comparison, materials collected from the shredded automobiles averaged 1,304 lb ferrous metals, 80 lb nonferrous metals, and 341 lb landfill materials. There were no materials used in the manufacture of the late model Japanese automobiles that should present handling or processing problems to the steelmaking or secondary metal recyclers.

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INTRODUCTION

Since the energy shortage crisis in the mid-1970's the popularity of smaller, fuel-efficient automobiles has resulted in downsizing, redesigning, and substitution of lighter weight materials in both domestic and foreign automobiles. Newly developed nonferrous metal alloys and high-strength low-alloy (HSLA) steels are being used to reduce automobile weights. The use of plastics also continues to increase.

Foreign automobile manufacturers, already producing compact and subcompact automobiles, quickly increased their exports to the United States, where most auto production was geared to larger cars. Expansion of existing technology was easier, less costly, and quicker for foreign automobile manufacturers to accomplish than was this country's retooling and redesigning of automobile production facilities. Today, Japanese imported automobiles account for approximately one-third of domestic new car sales (1).⁴

The changing automobile size and materials content potentially could affect the capability and technology of the automobile scrap processors. Junked automobile ferrous and nonferrous metals are a major scrap source for steel and secondary metal industries. The smaller automobiles contain less ferrous metals but as much or more nonferrous metals and nonmetals than most automobiles being junked today. Automobile shredders presently process 80 to 90 pct of the junked automobiles for metal recycling. These shredders tear and cut an automobile into fist-sized or smaller chunks in less than a minute. Ferrous metals are recovered by magnetic separation; nonmagnetic metals are recovered by air classification

or water elutriation (2-3). Nonmetal rejects are used as landfill.

In 1969, the Bureau of Mines completed research to determine the average composition of a typical automobile to determine the potential quantities of recoverable metals and nonmetals. A detailed hand-dismantled material classification was conducted on 15 junked automobiles (4) and showed that the circa 1960 "full-size" automobile contained, in pounds:

| | |
|--------------------------------|---------|
| Ferrous metals..... | 3,043.3 |
| Nonferrous metals..... | 157.1 |
| Rubber and combustibles..... | 172.2 |
| Glass and noncombustibles..... | 102.0 |
| Total..... | 3,574.6 |

The nonferrous metals included 20.4 lb battery lead.

The Bureau of Mines obtained four makes of 1981 and 1982 Japanese manufactured automobiles (fig. 1) to determine their materials content and if any of the materials used would present potential recycling problems. A three-phase study was conducted to--

1. Determine material composition of Japanese-imported automobiles by hand dismantling and categorizing.
2. Shred nearly identical model automobiles from each manufacturer to determine shredded component distribution.
3. Compare known metal contents of hand-dismantled automobiles with metals recovered from shredding.

The automobiles used in the study included three each of the following:

| | |
|--------------------|--------------------|
| 1981 Honda Accord | 1981 Datsun 210 |
| 1981 Toyota Tercel | 1982 Nissan Sentra |

⁴Underlined numbers in parentheses refer to items in the list of references at the end of this report.



FIGURE 1. - 1981 Honda Accord, 1981 Toyota Tercel, 1981 Datsun 210, and 1982 Nissan Sentra automobiles donated for the study.

ACKNOWLEDGMENTS

The Bureau of Mines gratefully acknowledges donations made by the American Honda Motor Co., Inc., for three new 1981 Honda Accord automobiles, Toyota Motor Sales USA, Inc., for three new 1981 Toyota Tercel automobiles, and Nissan Motor Corp. in USA for three new 1981 Datsun 210 automobiles and three new 1982 Nissan

Sentra automobiles used in the study. In addition, the Hugo Neu Steel Co., Salt Lake City, UT, shredded eight of the automobiles and assisted in collecting all products and rejects for analysis. The cooperation of these companies made this study possible.

PROCEDURES

HAND DISMANTLING

The automobiles to be dismantled were weighed, then systematically dismantled using common handtools plus air and electric-powered hammers, wrenches, chisels, and screwdrivers. Infrequently, an acetylene cutting torch was required for bimetal separations.

Each area of the automobile--interior, exterior, body, engine, and transmission--was systematically dismantled (fig. 2). Identification of components, materials, location, and weight data were continuously recorded during the progress of the work. Electronic components were removed from the automobiles as complete units, and weight data were obtained

before they were forwarded to the Bureau's Avondale Research Center for determining the precious metal content. After dismantling, material balances were obtained. All materials were categorically displayed, identified, and photographed (figs. 3-6). Each automobile was dismantled and categorized completely before progressing to the next one to avoid material loss or mixup.

The automobile compositions were calculated excluding batteries, fluids, and tools. A second composition was also calculated which excluded batteries, fluids, tools, gasoline tanks, wheels, and tires to represent the automobiles as they would be shredded.

SHREDDING

Automobile weights were obtained at the shredding site both before and after preparation for shredding. Preparation included removing the gasoline tanks (fig. 7), batteries, tires, and wheels. The shredding mill, transfer conveyors, dust collection systems, and processing classifiers were purged before shredding the test automobiles to remove residual metals and nonmetals hung up or trapped in the system during production operation. Paired automobiles were fed into the shredder (fig. 8), one behind the other. Two metal products and six reject stream discards were collected in containers, weighed, and taken to the Bureau



FIGURE 2. - Dismantling the 1981 Honda Accord.



KEY

- | | | |
|------------------------|---------------------|-------------------------|
| 1. Light iron | 10. Lead | 18. Heavy iron |
| 2. Glass | 11. Battery | 19. Chrome-plated steel |
| 3. Rubber | 12. Brass | 20. Hardened steel |
| 4. Vinyl | 13. Charcoal | 21. Cast steel |
| 5. Combustibles | 14. Circuit boards | 22. Spring steel |
| 6. Aluminum | 15. Stainless steel | 23. Polyurethane foam |
| 7. Catalytic converter | 16. Forged steel | 24. Plastic |
| 8. Zinc | 17. Cast iron | |
| 9. Coated copper wire | | |

FIGURE 3. - Dismantled and categorized 1981 Honda Accord.



KEY

- | | | |
|------------------------|------------------------|--------------------------------------|
| 1. Light iron | 10. Copper and brass | 18. Battery |
| 2. Rubber | 11. Coated copper wire | 19. Zinc |
| 3. Glass | 12. Vinyl | 20. Lead |
| 4. Cast iron | 13. Spring steel | 21. Asbestos |
| 5. Cast steel | 14. Aluminum | 22. Carbon |
| 6. Heavy iron | 15. Polyurethane foam | 23. Ceramic (catalytic converter) |
| 7. Chrome-plated steel | 16. Combustibles | 24. Ceramic |
| 8. Hardened steel | 17. Plastics | |
| 9. Stainless steel | | |

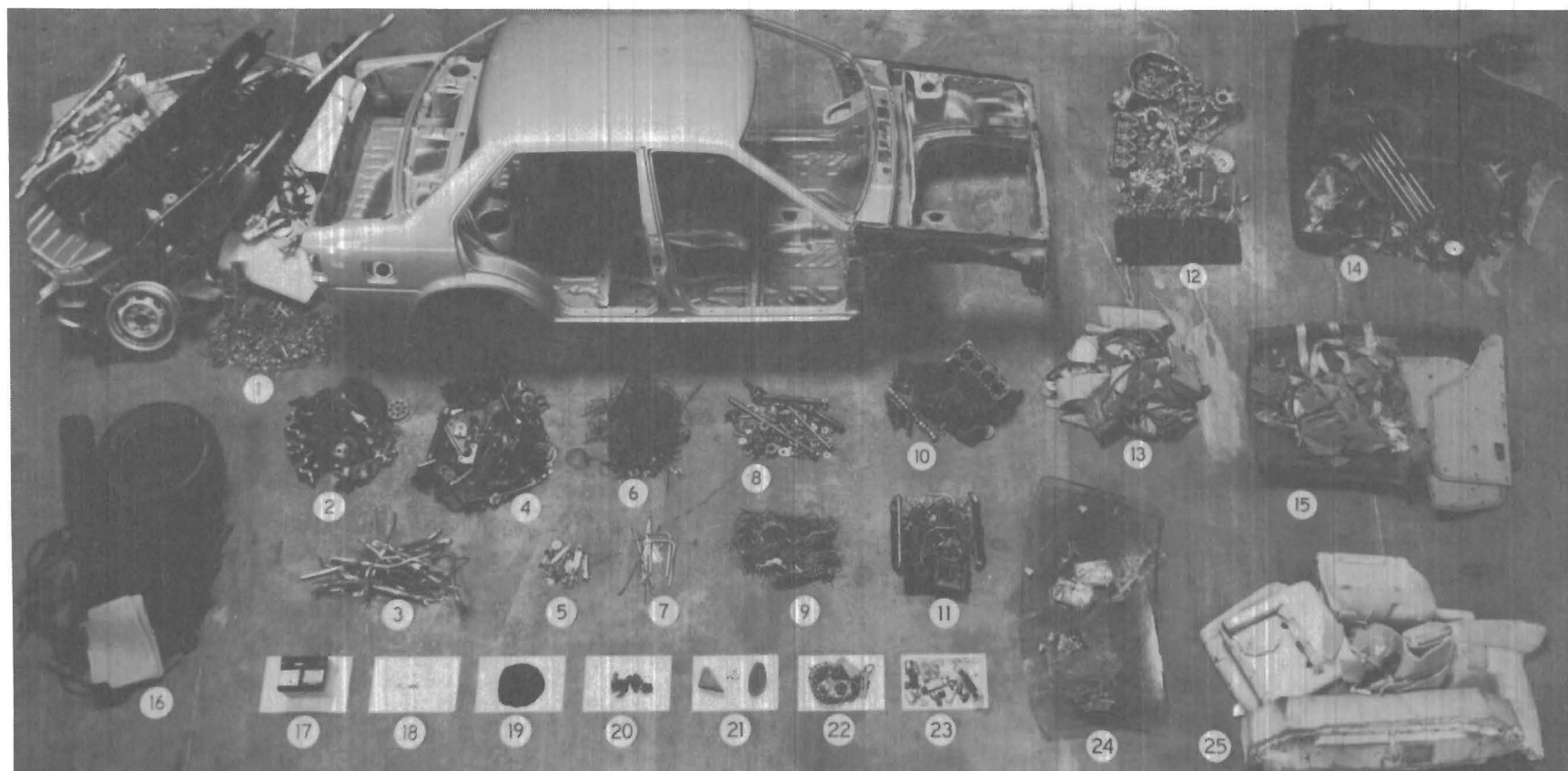
FIGURE 4. - Dismantled and categorized 1981 Toyota Tercel.



KEY

- | | | |
|------------------------|------------------------|-----------------------------------|
| 1. Light iron | 10. Rubber | 19. Electrical components |
| 2. Cast iron | 11. Glass | 20. Ceramic |
| 3. Cast steel | 12. Heavy iron | 21. Ceramic (catalytic converter) |
| 4. Hardened steel | 13. Brass and copper | 22. Carbon |
| 5. Spring steel | 14. Coated copper wire | 23. Asbestos |
| 6. Stainless steel | 15. Aluminum | 24. Lead |
| 7. Chrome-plated steel | 16. Vinyl | 25. Zinc |
| 8. Combustibles | 17. Plastic | |
| 9. Polyurethane foam | 18. Battery | |

FIGURE 5. - Dismantled and categorized 1981 Datsun 210.



KEY

- | | | |
|------------------------|----------------------|---------------------------|
| 1. Light iron | 10. Cast iron | 19. Carbon |
| 2. Cast steel | 11. Copper and brass | 20. Ceramic magnetic |
| 3. Stainless steel | 12. Aluminum | 21. Ceramic |
| 4. Heavy iron | 13. Vinyl | 22. Asbestos |
| 5. Zinc | 14. Plastic | 23. Electrical components |
| 6. Spring steel | 15. Combustibles | 24. Glass |
| 7. Chrome-plated steel | 16. Rubber | 25. Polyurethane foam |
| 8. Hardened steel | 17. Battery | |
| 9. Coated copper wire | 18. Lead | |

FIGURE 6. - Dismantled and categorized 1982 Nissan Sentra.



FIGURE 7. - Removing gas tank of 1981 Toyota Tercel prior to shredding.

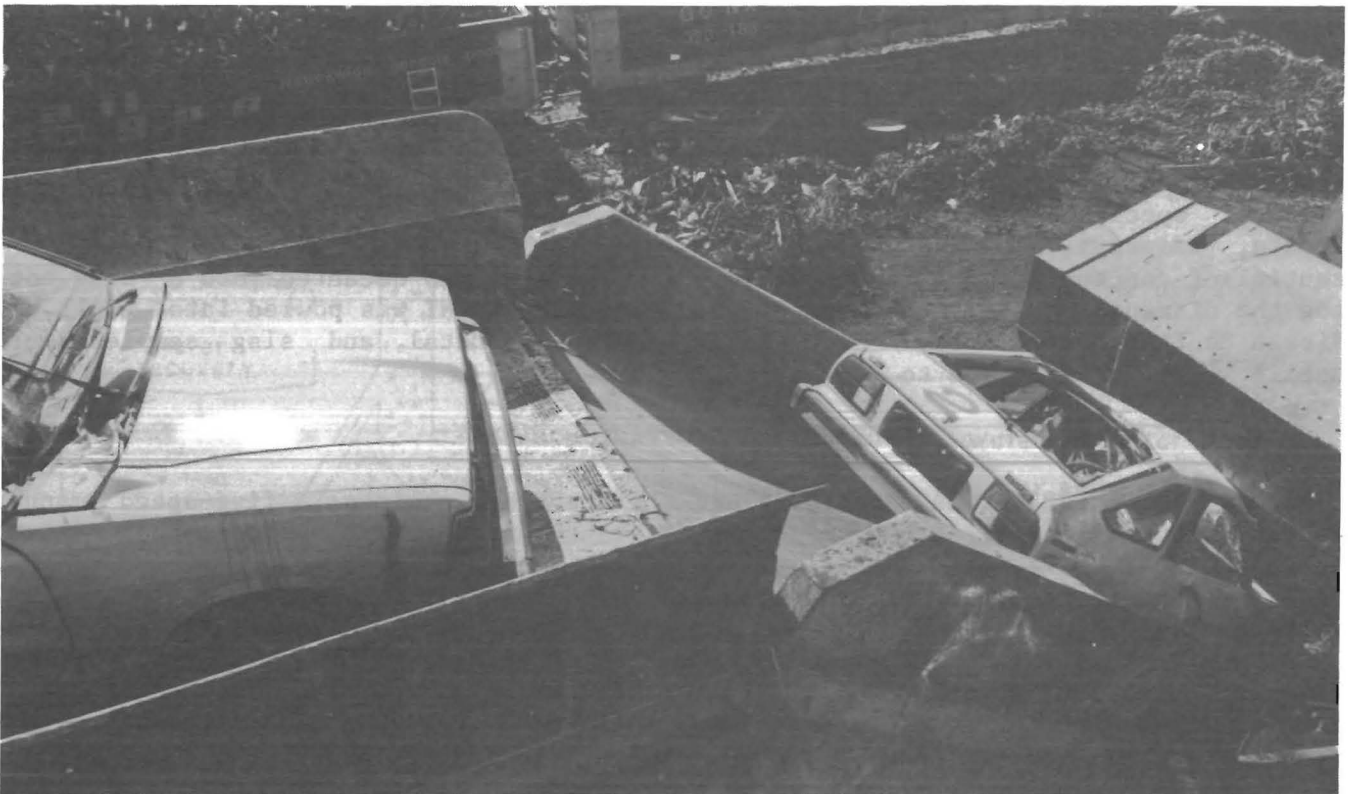


FIGURE 8. - Shredding 1981 Datsun 210's.

of Mines for analysis. Products and rejects were dried, if required, and hand-picked to separate metals and nonmetals into categories. Two or more different metals, physically attached, that could not be readily separated were classified with the major metal.

All tires and batteries were disposed of in accordance to donors' stipulations.

A schematic of the shredder operation is presented in figure 9. The collection sites for all products and rejects are highlighted.

HIGH-STRENGTH LOW-ALLOY STEEL MELTING TEST

The 1982 Nissan Sentra is the only automobile in the completed study to contain HSLA steel in significant quantities as shown in figure 10. HSLA steel is used to reduce the weight of the automobile as well as increase the strength of the structural supports.

There is concern among some U.S. foundries that the alloys in HSLA steels from shredded automobile scrap could detrimentally affect ferrous scrap metal processing or the quality of the iron products. There is also the realization that a separated HSLA steel scrap could be a premium product for recycling. For these reasons, special attention was taken to locate, identify, and determine the potential of concentrating HSLA steel during the dismantling and shredding of the Nissan Sentra automobiles. Each automobile contains from 186 to 206 lb HSLA

steel. Detailed locations of the HSLA steels contained in the automobiles were provided by the Nissan Motor Corp.

The entire ferrous product from one shredded Sentra was melted in the Bureau's Albany Research Center furnace to determine if the HSLA steel additions would adversely affect recycling of scrap steel.

The melting test was conducted in a three-phase ac, 1-ton-capacity, tiltable electric arc furnace. The furnace was filled with 1,197 lb magnetic metal scrap product from the Sentra; nonmetals physically attached to the ferrous product such as rubber, plastic, and upholstery were first removed by hand picking. The metal scrap was then melted down in the furnace. The melt was sampled and analyzed using a direct reading spectrograph.

Subsequently, 49.3 lb quartz and 51.5 lb limestone were added to the melt and rabbled to form a suitable slag. Then 5 lb FeMn was added to determine if the carbon and manganese levels could be increased. The melt was again sampled and analyzed.

The bath temperature was then increased from 1,540° to 1,618° C, to increase fluidity, and the furnace contents were tapped into a 1-ton-capacity ladle.

The slag was decanted into a slag pot, and the metal was poured into 60-lb pig molds. Metal and slag samples were taken.

DESCRIPTION OF AUTOMOBILES

Honda.--Three 1981 Honda Accord deluxe models; four-cylinder, 1,600-cm³ transverse engines; five-speed manual transmissions with front-wheel drive, equipped with power steering.

Toyota.--Two 1981 Toyota Corolla Tercel models, including standard and deluxe two-door sedans; four-cylinder, 1,500-cm³

transverse engines; five-speed manual transmissions with front-wheel drive, equipped with power steering.

One 1981 Toyota Corolla Tercel SR5 with a four-cylinder, 1,600-cm³ transverse engine and five-speed transmission. Deluxe model with sunroof, air conditioning and power steering.

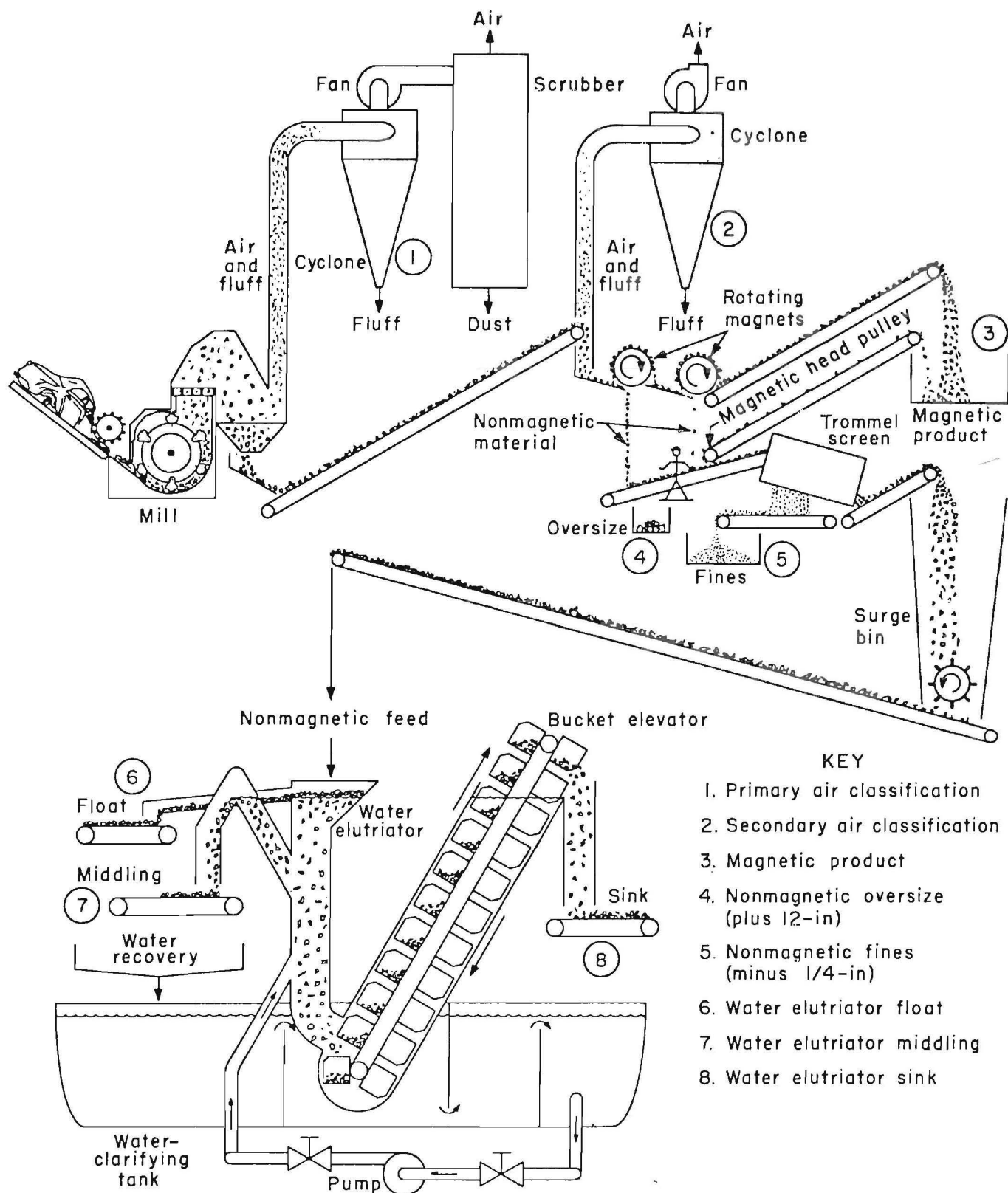


FIGURE 9. - Diagram of shredding and processing operation showing product and reject collection areas.



FIGURE 10. • HSLA steel application in 1982 Nissan Sentra.

Datsun.--Three 1981 Datsun 210 models, two-door hatchback coupes. Deluxe equipment package; four-cylinder, 1,500-cm³ engines and five-speed manual transmissions.

Sentra.--Three 1982 Nissan Sentra models, including two standard and one deluxe two-door sedans; four-cylinder, 1,500-cm³ engines; five-speed manual transmissions and front-wheel drive.

RESULTS

HAND DISMANTLING

Table 1 gives weights of the automobiles as received and as prepared for dismantling.

The completed hand dismantling study shows (see table 2) that the four models of Japanese automobiles averaged, in pounds:

| | |
|----------------------------|---------|
| Ferrous metals..... | 1,472.9 |
| Nonferrous metals..... | 115.6 |
| Combustibles..... | 275.2 |
| Noncombustibles..... | 72.3 |
| Electrical components..... | 2.3 |
| Total..... | 1,938.3 |

Light iron (<1/8 in thick) was the largest single weight category in all of the bodies. The heavier ferrous metals were concentrated in the engines, transmissions, drive trains, and suspensions. The ferrous metals comprised an average 76 pct of the automobiles' weight.

The nonferrous metal contents of the dismantled automobiles averaged, in pounds--

| | |
|-----------------------|-------|
| Aluminum..... | 84.6 |
| Copper and brass..... | 24.8 |
| Zinc diecast..... | 5.3 |
| Lead..... | .9 |
| Total..... | 115.6 |

Nonferrous metals averaged 6 pct of the automobiles' weight. Aluminum comprised over 73 pct of the nonferrous metals weight and was concentrated in the engines and transmissions. The Toyota Tercel also had aluminum wheels. Copper and brass were concentrated in dashboard and engine compartments as wiring and electrical components; however, they were found in smaller quantities throughout the entire automobile. The Honda Accord contained the greatest percentage of zinc diecast, mostly as knobs and switches with only minor engine usage. Lead tire weights were on all the automobiles.

Rubber and plastics were the primary combustibles. Glass was the major noncombustible.

Spectrographic analysis of the electronic components removed from the four automobiles as analyzed at the Avondale Research Center showed gold, silver, and palladium as alloying elements or trace contents. Indium was detected in several of the flasher units in the Datsun 210, which also contained more precious metals than the other automobiles. Soldered connections accounted for most of the silver detected.

TABLE 1. - Weights of the four Japanese automobiles as received and as prepared for hand dismantling, pounds

| | Honda | Toyota | Datsun | Nissan |
|-----------------------------|---------|---------|---------|---------|
| As received..... | 2,183 | 2,000 | 2,010 | 1,975 |
| Removed before dismantling: | | | | |
| Coolant..... | 10 | 11.9 | 12.1 | 15.1 |
| Oil and grease..... | 14 | 12.3 | 12.2 | 17.0 |
| Gasoline..... | 3.3 | 22.4 | 59.8 | 68.3 |
| Battery..... | 36 | 28.4 | 35.1 | 34.2 |
| Tools and lift..... | 7 | 4.6 | 5.4 | 5.7 |
| Total..... | 70.3 | 79.6 | 124.6 | 140.3 |
| To be dismantled..... | 2,112.7 | 1,920.4 | 1,885.4 | 1,834.7 |

TABLE 2. - Materials contained in four Japanese automobiles as determined by hand dismantling

| Class of material | 1981 Honda Accord | | 1981 Toyota Tercel | | 1981 Datsun 210 | | 1982 Nissan Sentra | | Combined average | |
|---|----------------------|--------------|-----------------------|--------------|--------------------|--------------|-----------------------|--------------|---------------------|--------------|
| | lb | pct | lb | pct | lb | pct | lb | pct | lb | pct |
| Ferrous: | | | | | | | | | | |
| Light iron..... | 1,079.6 | 51.1 | 958.1 | 49.9 | 754.2 | 40.0 | 671.6 | 36.6 | 865.9 | 44.7 |
| HSLA steel..... | 0 | 0 | 0 | 0 | 0 | 0 | 169.3 | 9.2 | 42.3 | 2.2 |
| Galvanized iron.. | 0 | 0 | .1 | 0 | 19.2 | 1.0 | 6.8 | .4 | 6.5 | .3 |
| Chrome-plated steel..... | 24.8 | 1.2 | 6.7 | .4 | 31.1 | 1.6 | 2.6 | .2 | 16.3 | .8 |
| Copper-coated iron..... | .1 | 0 | .1 | 0 | 0 | 0 | .2 | 0 | .1 | 0 |
| Spring steel..... | 30.1 | 1.4 | 36.5 | 1.9 | 39.5 | 2.1 | 25.8 | 1.4 | 33.0 | 1.7 |
| Steelplate..... | 183.3 | 8.7 | 84.0 | 4.3 | 277.5 | 14.7 | 201.5 | 11.0 | 186.6 | 9.6 |
| Hardened steel... | 85.2 | 4.0 | 91.0 | 4.7 | 135.3 | 7.2 | 50.0 | 2.7 | 90.4 | 4.7 |
| Cast iron..... | 128.0 | 6.1 | 101.7 | 5.3 | 146.4 | 7.8 | 113.5 | 6.2 | 122.4 | 6.3 |
| Cast steel..... | 92.9 | 4.4 | 104.7 | 5.5 | 54.0 | 2.9 | 139.8 | 7.6 | 97.8 | 5.1 |
| Stainless steel.. | 13.2 | .6 | 13.7 | .7 | 13.9 | .7 | 5.7 | .3 | 11.6 | .6 |
| Subtotal..... | 1,637.2 | 77.5 | 1,396.6 | 72.7 | 1,471.1 | 78.0 | 1,386.8 | 75.6 | 1,472.9 | 76.0 |
| Nonferrous: | | | | | | | | | | |
| Aluminum..... | 67.7 | 3.2 | ¹ 141.5 | 7.4 | 52.5 | 2.8 | 76.7 | 4.2 | 84.6 | 4.4 |
| Zinc..... | 10.8 | .5 | 5.4 | .3 | 2.0 | .1 | 2.9 | .2 | 5.3 | .3 |
| Lead ² | 1.2 | .1 | .6 | 0 | .9 | 0 | .9 | 0 | .9 | 0 |
| Copper and brass.. | 19.9 | 1.0 | 19.5 | 1.0 | 18.9 | 1.0 | 17.4 | 1.0 | 18.9 | 1.0 |
| Copper (wire) ³ ... | 7.2 | .3 | 5.0 | .3 | 5.1 | .3 | 6.4 | .3 | 5.9 | .3 |
| Subtotal..... | 106.8 | 5.1 | 172.0 | 9.0 | 79.4 | 4.2 | 104.3 | 5.7 | 115.6 | 6.0 |
| Combustibles: | | | | | | | | | | |
| Plastic (wire) ³ .. | 4.8 | .2 | 3.3 | .1 | 3.3 | .2 | 4.2 | .2 | 3.9 | .2 |
| Polyurethane foam | 22.7 | 1.1 | 24.4 | 1.3 | 19.6 | 1.1 | 22.7 | 1.2 | 22.3 | 1.2 |
| Vinyl..... | 13.4 | .6 | 14.0 | .7 | 13.9 | .7 | 8.8 | .5 | 12.5 | .6 |
| Other plastics... | 82.5 | 3.9 | 75.1 | 3.9 | 64.8 | 3.4 | 67.0 | 3.7 | 72.4 | 3.8 |
| Rubber ⁴ | 144.7 | 6.9 | 101.3 | 5.3 | 103.2 | 5.5 | 117.3 | 6.4 | 116.6 | 6.0 |
| Carbon..... | .6 | 0 | 1.8 | .1 | .7 | 0 | .7 | 0 | 1.0 | 0 |
| Other combustibles.... | 32.3 | 1.5 | 45.2 | 2.4 | 52.2 | 2.8 | 56.2 | 3.1 | 46.5 | 2.4 |
| Subtotal..... | 301.0 | 14.2 | 265.1 | 13.8 | 257.7 | 13.7 | 276.9 | 15.1 | 275.2 | 14.2 |
| Noncombustibles: | | | | | | | | | | |
| Ceramics..... | 2.9 | .1 | 4.8 | .2 | 3.3 | .2 | 4.0 | .2 | 3.8 | .1 |
| Glass..... | 63.0 | 3.0 | 80.0 | 4.2 | 68.6 | 3.6 | 57.8 | 3.1 | 67.3 | 3.5 |
| Asbestos..... | 1.2 | .1 | 1.5 | .1 | 1.1 | .1 | 1.1 | .1 | 1.2 | .1 |
| Subtotal..... | 67.1 | 3.2 | 86.3 | 4.5 | 73.0 | 3.9 | 62.9 | 3.4 | 72.3 | 3.7 |
| Electric components⁵..... | .6 | 0 | .4 | Trace | 4.2 | .2 | 3.8 | .2 | 2.3 | .1 |
| Total..... | 2,112.7 | 100.0 | 1,920.4 | 100.0 | 1,885.4 | 100.0 | 1,834.7 | 100.0 | 1,938.3 | 100.0 |

¹The high aluminum content of the Toyota is attributed to aluminum wheels.

²Excluding batteries, which were not used in composition calculations.

³The plastic-coated wire was stripped to obtain a 60 copper-40 coating weight ratio.

⁴The steel-belted radial tires were weighed as rubber; however, they can contain up to 30 pct steel wire.

⁵Electrical components such as circuit boards and relays were weighed as single units and forwarded to the Bureau of Mines Avondale Research Center for precious metal identification.

SHREDDING

Collected shredded products and rejects from each pair of shredded automobiles varied in total weight from a 6.0-pct loss to a 9.2-pct gain of the prepared automobile weights, as shown in the shredded materials distribution in table 3. Losses and gains in weights are common in batch-type operations of the shredding process.

The distribution of products and rejects from processing shredded automobiles followed the typical pattern. The air classification systems collected most of the combustibles, and magnetic

separation removed most of the iron. The fines collected from screening the nonmagnetic material contained most of the noncombustibles. Screened nonmagnetics processed by water elutriation yielded a clean, mixed nonmagnetic metal sink product and two reject fractions. The float and middling reject fractions from water elutriation contained both combustibles and noncombustibles. Tables 4 through 7 show the analysis and weight distribution of the products and rejects from each of the shredded automobiles.

Data from table 8 show a ferrous metal recovery of 99.2 pct and a nonferrous metal recovery of 79 pct.

TABLE 3. - Material distribution of the collected products and rejects obtained from shredding and processing four Japanese automobiles

| Shredder products and rejects | 1981 Honda Accord | 1981 Toyota Tercel | 1981 Datsun 210 | 1982 Nissan Sentra | Average |
|---|-------------------------|--------------------------|-----------------------|--------------------------|------------------|
| Prepared weight to auto shredder.....lb.. | 1,900 | 1,670 | 1,790 | 1,570 | 1,732.5 |
| Combined recovered weight.....lb.. | 1,785.9 | ¹ 1,822.8 | ¹ 1,712.3 | ¹ 1,579.1 | 1,725.0 |
| Primary air classification.....pct.. | 6.2 | 11.6 | 8.2 | 6.2 | 8.0 |
| Secondary air classification.....pct.. | 5.5 | 7.3 | 5.1 | 4.9 | 5.7 |
| Magnetic product.....pct.. | 73.2 | 78.7 | 73.4 | 76.7 | 75.4 |
| Nonmagnetic oversize..pct.. | .2 | .2 | .6 | ² 5.5 | ³ 3.4 |
| Nonmagnetic fines.....pct.. | 2.0 | 3.2 | 2.4 | (²) | (³) |
| Water elutriator, pct: | | | | | |
| Float..... | 2.5 | 1.6 | 1.4 | .2 | 1.5 |
| Middling..... | ⁴ Trace | 1.5 | 1.2 | 1.2 | .9 |
| Sink..... | 4.4 | 5.1 | 3.4 | 6.0 | 4.7 |
| Total.....pct.. | 94.0 | 109.2 | 95.7 | 100.7 | 99.6 |
| Material balance.....pct.. | -6.0 | +9.2 | -4.3 | +7 | -.4 |

¹Weight gains are attributed to materials missed when the system was purged prior to shredding the cars.

²A tertiary air classifier was substituted for screen sizing for the Nissan Sentra processing; rejects were collected as 1 unit.

³Average is for the combined oversize and fines from all automobiles, as air classifying the Sentra distorted the results.

⁴The minimal amount of middling product collected from processing the Hondas was combined with the float product.

TABLE 4. - Analysis and weight distribution of metal products and rejects obtained from shredding a 1981 Honda Accord automobile,¹ pounds

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| Class of material | Metal products | | Rejects | | | | | Combined totals |
|-----------------------------------|----------------|-------------|--------------|---------------|-------------------------------|--------------------|-------------------------------------|-----------------|
| | Magnetic | Nonmagnetic | Primary air | Secondary air | Nonmagnetic oversize (>12 in) | Minus 1/2-in fines | Water elutriator float and middling | |
| Ferrous: | | | | | | | | |
| Light iron..... | 901.2 | 0.6 | 5.0 | 1.9 | 0 | 0.4 | Trace | 909.1 |
| Chrome-plated steel. | .7 | 0 | 0 | 0 | 0 | 0 | 0 | .7 |
| Spring steel..... | 30.3 | Trace | .3 | .2 | 0 | .7 | Trace | 31.5 |
| Steelplate..... | 270.0 | 3.3 | 9.9 | 0 | 0 | 0 | 0 | 283.2 |
| Hardened steel..... | ND | ND | ND | ND | ND | ND | ND | ND |
| Cast iron..... | 155.7 | 8.5 | 0 | 1.8 | 0 | 1.7 | Trace | 167.7 |
| Cast steel..... | ND | ND | ND | ND | ND | ND | ND | ND |
| Stainless steel..... | 2.2 | 6.3 | .1 | .4 | 0 | Trace | Trace | 9.0 |
| Minus 1/4 in..... | 9.7 | 0 | 0 | 0 | 0 | 0 | 0 | 9.7 |
| Subtotal..... | 1,369.8 | 18.7 | 15.3 | 4.3 | 0 | 2.8 | Trace | 1,410.9 |
| Nonferrous: | | | | | | | | |
| Aluminum..... | 2.1 | 41.9 | .3 | .3 | 0 | 4.0 | .2 | 48.8 |
| Zinc..... | 0 | 5.1 | 0 | 0 | 0 | .1 | Trace | 5.2 |
| Lead..... | 0 | .1 | 0 | 0 | 0 | Trace | Trace | .1 |
| Copper and brass.... | 4.4 | 8.9 | .1 | .2 | 0 | 1.2 | .3 | 15.1 |
| Copper-coated wire ² . | 1.2 | 2.3 | .6 | .6 | 0 | .3 | 2.0 | 7.0 |
| Subtotal..... | 7.7 | 58.3 | 1.0 | 1.1 | 0 | 5.6 | 2.5 | 76.2 |
| Combustibles: | | | | | | | | |
| Polyurethane foam... | .1 | Trace | 13.2 | 7.5 | 0 | .2 | 3.4 | 24.4 |
| Vinyl..... | 2.8 | 0 | 3.6 | 4.0 | 0 | Trace | 2.0 | 12.4 |
| Other plastics..... | .5 | .7 | 6.0 | 14.2 | 1.6 | 3.6 | 23.8 | 50.4 |
| Rubber..... | 6.2 | 5.5 | 2.8 | 1.7 | 1.7 | 1.0 | 11.9 | 30.8 |
| Other combustibles.. | 3.0 | .1 | 40.4 | 30.8 | 0 | 2.8 | 4.2 | 81.3 |
| Subtotal..... | 12.6 | 6.3 | 66.0 | 58.2 | 3.3 | 7.6 | 45.3 | 199.3 |
| Noncombustibles: | | | | | | | | |
| Glass..... | 0 | .2 | 0 | 0 | 0 | .1 | .2 | .5 |
| Asbestos..... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subtotal..... | 0 | .2 | 0 | 0 | 0 | .1 | .2 | .5 |
| Nonmagnetic: | | | | | | | | |
| Minus 1/4 in..... | 0 | .2 | 34.8 | 40.9 | 0 | 22.6 | .5 | 99.0 |
| Total..... | 1,390.1 | 83.7 | 117.1 | 104.5 | 3.3 | 38.7 | 48.5 | 1,785.9 |

ND Not determined.

¹2 Honda Accords were shredded. The data shown have been adjusted to represent 1 automobile.

²Average analysis for coated copper wire: 60 pct copper, 40 pct coating.

TABLE 5. - Analysis and weight distribution of metal products and rejects obtained from shredding a 1981 Toyota Tercel automobile,¹ pounds

| Class of material | Metal products | | Rejects | | | | | | Combined totals |
|---------------------------------|----------------|------------------|------------------|------------------|-------------------------------------|------------------------|------------------------------|---------------------------------|-----------------|
| | Magnetic | Nonmag- netic | Primary air | Secondary air | Nonmagnetic oversize (>12 in) | Minus 1/2- in fines | Water elutriator float | Water elutriator middling | |
| Ferrous: | | | | | | | | | |
| Light iron..... | 812.9 | 1.8 | 3.9 | 0.3 | 0 | <0.1 | 0.6 | 0.1 | 819.7 |
| Chrome-plated steel | 4.9 | 0 | 0 | Trace | 0 | .1 | 0 | 0 | 5.0 |
| Spring steel..... | 35.0 | 0 | .3 | .3 | 0 | <.1 | 0 | 0 | 35.7 |
| Steelplate..... | 154.7 | 0 | .2 | 0 | 0 | 0 | 0 | 0 | 154.9 |
| Hardened steel..... | 58.1 | 0 | .2 | 0 | 0 | .2 | 0 | 0 | 58.5 |
| Cast iron..... | 77.8 | 0 | .6 | 0 | 0 | .4 | 0 | 0 | 78.8 |
| Cast steel..... | 120.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 120.2 |
| Stainless steel..... | 2.3 | 2.5 | 0 | Trace | 0 | .2 | Trace | Trace | 5.0 |
| Minus 1/4 in..... | 35.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 35.3 |
| Subtotal..... | 1,301.2 | 4.3 | 5.2 | .6 | 0 | 1.1 | .6 | .1 | 1,313.1 |
| Nonferrous: | | | | | | | | | |
| Aluminum..... | 2.0 | 61.7 | <.1 | .1 | 0 | 2.9 | .2 | .4 | 67.4 |
| Zinc..... | 0 | 2.9 | 0 | 0 | 0 | <.1 | 0 | 0 | 3.0 |
| Lead..... | 0 | .2 | 0 | 0 | 0 | 0 | 0 | 0 | .2 |
| Copper and brass... | 1.9 | 11.7 | <.1 | .1 | .8 | 1.2 | <.1 | .3 | 16.2 |
| Coated-copper wire ² | 1.3 | .7 | .1 | .3 | 0 | .3 | 1.1 | 1.3 | 5.1 |
| Subtotal..... | 5.2 | 77.2 | .3 | .5 | .8 | 4.5 | 1.4 | 2.0 | 91.9 |
| Combustibles: | | | | | | | | | |
| Polyurethane foam.. | .4 | 0 | (³) | (³) | 0 | 0 | 1.7 | Trace | 2.1 |
| Vinyl..... | 1.4 | 0 | (³) | (³) | 0 | 0 | 1.5 | .1 | 3.0 |
| Other plastics..... | .2 | .9 | (³) | (³) | 1.1 | 7.0 | 13.6 | 5.3 | 28.1 |
| Rubber..... | 2.8 | 2.6 | (³) | (³) | 1.3 | 1.0 | 6.1 | 15.6 | 29.4 |
| Other combustibles. | .9 | .3 | 87.6 | 62.5 | 0 | 2.6 | 1.6 | 1.0 | 156.5 |
| Subtotal..... | 5.7 | 3.8 | 87.6 | 62.5 | 2.4 | 10.6 | 24.5 | 22.0 | 219.1 |
| Noncombustibles: | | | | | | | | | |
| Glass..... | Trace | Trace | Trace | .1 | 0 | 1.5 | 0 | Trace | 1.6 |
| Asbestos..... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subtotal..... | Trace | Trace | Trace | .1 | 0 | 1.5 | 0 | Trace | 1.6 |
| Nonmagnetic: | | | | | | | | | |
| Minus 1/4 in..... | 2.2 | .1 | 100.8 | 57.4 | 0 | 35.3 | .8 | .5 | 197.1 |
| Total..... | 1,314.3 | 85.4 | 193.9 | 121.1 | 3.2 | 53.0 | 27.3 | 24.6 | 1,822.8 |

¹2 Toyota Tercels were shredded. The data shown have been adjusted to represent 1 automobile.

²Average analysis for coated copper wire: 60 pct copper, 40 pct coating.

³Combined with other combustibles.

TABLE 6. - Analysis and weight distribution of metal products and rejects obtained from shredding a 1981 Datsun 210 automobile,¹ pounds

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| Class of material | Metal products | | Rejects | | | | | | Combined totals |
|---------------------------------|----------------|-------------|------------------|------------------|-------------------------------|--------------------|------------------------|---------------------------|-----------------|
| | Magnetic | Nonmagnetic | Primary air | Secondary air | Nonmagnetic oversize (>12 in) | Minus 1/2-in fines | Water elutriator float | Water elutriator middling | |
| Ferrous: | | | | | | | | | |
| Light iron..... | 690.7 | 2.2 | 4.1 | 0.6 | 1.2 | 1.3 | 0.6 | 0.2 | 700.9 |
| Chrome-plated steel | 17.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17.9 |
| Spring steel..... | 32.6 | 1.1 | .2 | .1 | .1 | Trace | Trace | .1 | 34.2 |
| Heavy iron..... | 254.8 | .2 | 0 | 0 | 0 | 0 | 0 | 0 | 255.0 |
| Hardened steel..... | 60.4 | .8 | Trace | 0 | 0 | .2 | 0 | 0 | 61.4 |
| Cast iron..... | 113.4 | 1.6 | .5 | 0 | 0 | 0 | 0 | 0 | 115.5 |
| Cast steel..... | 93.2 | .2 | 0 | 0 | 0 | 0 | 0 | 0 | 93.4 |
| Stainless steel.... | 6.8 | 2.3 | .4 | Trace | 0 | .2 | 0 | Trace | 9.7 |
| Minus 1/4 in..... | 17.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17.0 |
| Subtotal..... | 1,286.8 | 8.4 | 5.2 | .7 | 1.3 | 1.7 | .6 | .3 | 1,305.0 |
| Nonferrous: | | | | | | | | | |
| Aluminum..... | 4.7 | 31.1 | .3 | Trace | 0 | 1.6 | .2 | .4 | 38.3 |
| Zinc..... | 1.7 | 6.0 | 0 | 0 | 0 | .3 | 0 | 0 | 8.0 |
| Lead..... | 0 | .1 | 0 | 0 | 0 | 0 | 0 | 0 | .1 |
| Copper and brass... | 2.5 | 5.6 | .1 | .2 | 2.1 | .5 | .4 | .3 | 11.7 |
| Coated copper wire ² | 1.9 | .9 | .5 | .5 | Trace | .2 | 2.9 | .9 | 7.8 |
| Subtotal..... | 10.8 | 43.7 | .9 | .7 | 2.1 | 2.6 | 3.5 | 1.6 | 65.9 |
| Combustibles: | | | | | | | | | |
| Polyurethane foam.. | .6 | 0 | (³) | (³) | .2 | 0 | 1.5 | 0 | 2.3 |
| Vinyl..... | 2.8 | 0 | (³) | (³) | 1.2 | 0 | 2.1 | .8 | 6.9 |
| Other plastics..... | 1.7 | 1.0 | (³) | (³) | 3.8 | 3.2 | 9.0 | 5.5 | 24.2 |
| Rubber..... | 5.3 | 7.0 | (³) | (³) | 2.7 | .7 | 3.7 | 9.8 | 29.2 |
| Other combustibles. | 3.9 | .2 | 99.5 | 52.0 | .1 | .6 | 2.7 | 2.4 | 161.4 |
| Subtotal..... | 14.3 | 8.2 | 99.5 | 52.0 | 8.0 | 4.5 | 19.0 | 18.5 | 224.0 |
| Noncombustibles: | | | | | | | | | |
| Glass..... | 0 | .4 | 0 | .1 | 0 | .2 | .9 | .2 | 1.8 |
| Asbestos..... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subtotal..... | 0 | .4 | 0 | .1 | 0 | .2 | .9 | .2 | 1.8 |
| Nonmagnetic: | | | | | | | | | |
| Minus 1/4 in..... | 1.8 | .1 | 41.1 | 36.8 | 0 | 33.2 | 1.7 | .9 | 115.6 |
| Total..... | 1,313.7 | 60.8 | 146.7 | 90.3 | 11.4 | 42.2 | 25.7 | 21.5 | 1,712.3 |

¹2 Datsun 210's were shredded. The data shown have been adjusted to represent 1 automobile.

²Average analysis for coated copper wire: 60 pct copper, 40 pct coating.

³Combined with other combustibles.

TABLE 7. - Analysis and weight distribution of metal products and rejects obtained from shredding a 1982 Nissan Sentra automobile,¹ pounds

| Class of material | Metal products | | Rejects | | | | | Combined totals |
|---------------------------------------|----------------|------------------|------------------|------------------|------------------------------|------------------------------|---------------------------------|-----------------|
| | Magnetic | Nonmag- netic | Primary air | Secondary air | Tertiary air ² | Water elutriator float | Water elutriator middling | |
| Ferrous: | | | | | | | | |
| Light iron..... | 765.1 | 0.7 | 0.6 | 0.1 | 0 | 0 | Trace | 766.5 |
| Chrome-plated steel..... | 1.3 | 0 | .1 | Trace | 0 | 0 | 0 | 1.4 |
| Spring steel..... | 35.6 | .1 | Trace | .2 | Trace | 0 | 0 | 35.9 |
| Steelplate..... | 153.2 | 0 | 0 | 0 | 0 | 0 | 0 | 153.2 |
| Hardened steel..... | 17.9 | 0 | 0 | 0 | 0 | 0 | 0 | 17.9 |
| Cast iron..... | 104.3 | .2 | Trace | 0 | 0 | 0 | Trace | 104.5 |
| Cast steel..... | 93.8 | 0 | 0 | 0 | 0 | 0 | 0 | 93.8 |
| Stainless steel..... | 1.6 | 2.6 | Trace | .1 | .4 | Trace | Trace | 4.7 |
| Minus 1/4 in..... | 9.0 | 0 | 0 | 0 | 0 | 0 | 0 | 9.0 |
| Subtotal..... | 1,181.8 | 3.6 | .7 | .4 | .4 | Trace | Trace | 1,186.9 |
| Nonferrous: | | | | | | | | |
| Aluminum..... | 5.1 | 63.1 | .2 | .2 | .3 | .1 | .4 | 69.4 |
| Zinc..... | 0 | 2.2 | Trace | Trace | Trace | 0 | Trace | 2.2 |
| Lead..... | 0 | .5 | 0 | 0 | 0 | 0 | 0 | .5 |
| Copper and brass..... | 2.9 | 12.1 | .2 | .2 | 1.4 | Trace | Trace | 16.8 |
| Coated copper wire ³ | 2.0 | .6 | .2 | .4 | 5.0 | Trace | .2 | 8.4 |
| Subtotal..... | 10.0 | 78.5 | .6 | .8 | 6.7 | .1 | .6 | 97.3 |
| Combustibles: | | | | | | | | |
| Polyurethane foam..... | .6 | 0 | (⁴) | (⁴) | 1.1 | Trace | Trace | 1.7 |
| Vinyl..... | 1.6 | 0 | (⁴) | (⁴) | 2.4 | 0 | Trace | 4.0 |
| Other plastics..... | 2.9 | .3 | (⁴) | (⁴) | 27.6 | .8 | 1.1 | 32.7 |
| Rubber..... | 4.6 | 4.9 | (⁴) | (⁴) | 9.3 | 1.7 | 14.7 | 35.2 |
| Other combustibles..... | 1.7 | .6 | 73.7 | 49.5 | 5.5 | .3 | 1.7 | 133.0 |
| Subtotal..... | 11.4 | 5.8 | 73.7 | 49.5 | 45.9 | 2.8 | 17.5 | 206.6 |
| Noncombustibles: | | | | | | | | |
| Ceramics..... | .3 | 0 | 0 | 0 | 0 | 0 | 0 | .3 |
| Glass..... | .1 | .1 | .1 | .2 | 1.7 | 0 | .1 | 2.3 |
| Asbestos..... | 0 | 0 | 0 | Trace | 0 | 0 | 0 | Trace |
| Subtotal..... | .4 | .1 | .1 | .2 | 1.7 | 0 | .1 | 2.6 |
| Nonmagnetic: | | | | | | | | |
| Minus 1/4 in..... | 0 | 6.7 | 20.1 | 26.4 | 32.1 | .1 | .3 | 85.7 |
| Total..... | 1,203.6 | 94.7 | 95.2 | 77.3 | 86.8 | 3.0 | 18.5 | 1,579.1 |

¹2 Nissan Sentras were shredded. The data shown have been adjusted to represent 1 automobile.

²Fines and oversize were not removed by screening. A 3d air classification was used.

³Average analysis for coated copper wire: 60 pct copper, 40 pct coating.

⁴Combined with other combustibles.

TABLE 8. - Metals recovered compared with total metals contained in the magnetic and nonmagnetic shredded products of Japanese automobiles¹

| Metals | Total metals collected, lb | Recovered metals, ² lb | Shredded metal recovery versus collected shredded metals, pct |
|---------------------------|----------------------------|-----------------------------------|---|
| Ferrous metals..... | 1,304.0 | 1,293.7 | 99.2 |
| Nonferrous metals: | | | |
| Aluminum..... | 56.0 | 49.4 | 88.2 |
| Zinc..... | 4.6 | 4.1 | 89.1 |
| Lead..... | .2 | .1 | 50.0 |
| Copper and brass..... | 15.0 | 9.6 | 64.0 |
| Copper (coated wire)..... | 4.2 | 0 | 0 |
| Subtotal..... | 80.0 | 63.2 | 79.0 |
| Total..... | 1,384.0 | 1,356.9 | 98.0 |

¹The metal weights shown are average weights from the combined automobiles.

²Recovered metals are collected in the magnetic and elutriated products. Nonferrous metals in the collected magnetic product and copper from coated wire were not recovered.

COMPARISON OF RECOVERED SHREDDED PRODUCTS AND HAND-DISMANTLED AUTOMOBILE CONTENTS

The Japanese automobiles contained a greater percentage of light gage steel than the previously dismantled automobiles (4), and the Sentra contained a significant amount of HSLA steel. The Japanese automobiles also contained a significantly higher percentage of aluminum, which comprised more than 73 pct of the nonferrous metal content. Tables 9 and 10 compare the materials collected from shredded automobiles with the corresponding materials in the dismantled automobiles. Metal losses after shredding were noted in both the ferrous and nonferrous metal categories, with some inconsistencies in the ferrous metal category when compared to the dismantling data. These were attributed to difficulties in identification of the shredded metals, which are discolored, squeezed together, and often not separable.

Apparent metal losses in material hang-ups occurred throughout the system when shredding only two automobiles at a time without purging the entire shredding system after processing the cars. The losses appear excessive, but during operation the system is continuously purging so the losses would become insignificant compared to the total throughput. Other losses were attributed to brittle metals

such as cast iron, aluminum, and zinc diecast, which shattered and were lost to the fines, were removed as dirt in the air collection system, or became part of the sludge in the elutriation system.

The combustibles showed little difference between the dismantled contents and the shredded rejects. There were differences in noncombustibles because glass from the shredded automobiles was collected in the minus 1/4-in rejects, which were not analyzed.

An averaged weight comparison of the metals recovered with the total metals contained in the shredded magnetic and nonmagnetic products is shown in table 8. A similar weight comparison of the averaged metals recovered from shredded automobiles with the metal content of similar dismantled automobiles is presented in table 11.

Metal recovery based upon the total collected shredded materials averaged 99.2 pct for ferrous and 79.0 pct for nonferrous metals. Compared to the dismantled automobile weights, the averaged recoveries were 93.1 pct for the ferrous metals and 62.2 pct for the nonferrous metals.

TABLE 9. - Comparison of materials determined by hand dismantling and collected from shredding the Honda and Toyota automobiles¹

| Class of material | 1981 Honda Accord | | | | 1981 Toyota Tercel | | | |
|-------------------------|-------------------|--------------|----------------|--------------|--------------------|--------------|--------------------|--------------|
| | Dismantled | | Shredded | | Dismantled | | Shredded | |
| | lb | pct | lb | pct | lb | pct | lb | pct |
| Ferrous: | | | | | | | | |
| Light iron..... | 1,054.9 | 54.3 | 909.1 | 50.9 | 939.1 | 52.4 | 819.7 | 45.0 |
| Galvanized iron..... | 0 | 0 | 0 | 0 | .1 | Trace | 0 | 0 |
| Copper-coated iron..... | .1 | 0 | 0 | 0 | 6.7 | .4 | 0 | 0 |
| Chrome-plated steel.... | 24.8 | 1.3 | .7 | Trace | .1 | Trace | 5.0 | .3 |
| Spring steel..... | 30.1 | 1.6 | 31.5 | 1.8 | 36.4 | 2.0 | 35.7 | 2.0 |
| Steelplate..... | 181.2 | 9.3 | 283.2 | 15.9 | 69.2 | 3.9 | 154.9 | 8.5 |
| Hardened steel..... | ND | ND | ND | ND | 91.0 | 5.1 | 58.5 | 3.2 |
| Cast iron..... | 128.0 | 6.6 | 167.7 | 9.4 | 101.7 | 5.7 | 78.8 | 4.3 |
| Cast steel..... | 92.9 | 4.8 | ND | ND | 104.7 | 5.8 | 120.2 | 6.6 |
| Stainless steel..... | 13.2 | .7 | 9.0 | .5 | 13.7 | .8 | 5.0 | .3 |
| Minus 1/4 in..... | 0 | 0 | 9.7 | .5 | 0 | 0 | 35.3 | 1.9 |
| Subtotal..... | 1,525.2 | 78.6 | 1,410.9 | 79.0 | 1,362.7 | 76.1 | 1,313.1 | 72.1 |
| Nonferrous: | | | | | | | | |
| Aluminum..... | 67.7 | 3.5 | 48.8 | 2.7 | 87.5 | 4.9 | 67.4 | 3.7 |
| Zinc..... | 10.8 | .6 | 5.2 | .3 | 5.4 | .3 | 3.0 | .1 |
| Lead..... | .6 | Trace | .1 | Trace | .4 | Trace | .2 | Trace |
| Copper and brass..... | 19.9 | 1.0 | 15.1 | .9 | 19.4 | 1.1 | 16.2 | .9 |
| Copper (coated wire)... | 7.2 | .4 | 4.2 | .2 | 5.0 | .3 | 3.1 | .2 |
| Subtotal..... | 106.2 | 5.5 | 73.4 | 4.1 | 117.7 | 6.6 | 89.9 | 4.9 |
| Combustibles: | | | | | | | | |
| Plastic (coated wire).. | 4.8 | .3 | 2.8 | .2 | 3.3 | .2 | 2.0 | .1 |
| Polyurethane foam..... | 22.7 | 1.2 | 24.4 | 1.4 | 24.4 | 1.4 | 2.1 | .1 |
| Vinyl..... | 13.4 | .7 | 12.4 | .7 | 14.0 | .8 | 3.0 | .2 |
| Other plastics..... | 82.5 | 4.2 | 50.4 | 2.8 | 74.7 | 4.2 | 28.1 | 1.5 |
| Rubber..... | 62.2 | 3.2 | 30.8 | 1.7 | 36.4 | 2.0 | 29.4 | 1.6 |
| Carbon..... | .6 | Trace | 0 | 0 | 1.8 | .1 | 0 | 0 |
| Other combustibles..... | 32.9 | 1.7 | 81.3 | 4.6 | 45.6 | 2.5 | ² 156.5 | 8.6 |
| Subtotal..... | 219.1 | 11.3 | 202.1 | 11.4 | 200.2 | 11.2 | 221.1 | 12.1 |
| Noncombustibles: | | | | | | | | |
| Ceramics..... | 2.9 | .1 | 0 | 0 | 4.8 | .2 | 0 | 0 |
| Glass..... | 63.0 | 3.2 | .5 | Trace | 80.0 | 4.5 | 1.6 | .1 |
| Asbestos..... | 1.2 | .1 | 0 | 0 | 1.5 | .1 | 0 | 0 |
| Subtotal..... | 67.1 | 3.4 | .5 | Trace | 86.3 | 4.8 | 1.6 | .1 |
| Nonmagnetic: | | | | | | | | |
| Minus 1/4 in..... | 0 | 0 | 99.0 | 5.5 | 0 | 0 | 197.1 | 10.8 |
| Fluids..... | 24.2 | 1.2 | ND | ND | 24.2 | 1.3 | ND | ND |
| Total..... | 1,941.8 | 100.0 | 1,785.9 | 100.0 | 1,791.1 | 100.0 | 1,822.8 | 100.0 |

ND Not determined separately--included with steelplate.

¹The weights of the shredded materials are representative of 1 automobile.²Includes the weight of all combustibles from the air classification systems.

TABLE 10. - Comparison of materials determined by hand dismantling and collected from shredding the Datsun and Sentra automobiles¹

| Class of material | 1981 Datsun 210 | | | | 1982 Nissan Sentra | | | |
|-------------------------|-----------------|--------------|--------------------|--------------|--------------------|--------------|--------------------|--------------|
| | Dismantled | | Shredded | | Dismantled | | Shredded | |
| | lb | pct | lb | pct | lb | pct | lb | pct |
| Ferrous: | | | | | | | | |
| Light iron..... | 727.9 | 41.4 | 700.9 | 40.9 | 821.1 | 48.4 | 766.5 | 48.6 |
| Galvanized iron..... | 19.2 | 1.1 | 0 | 0 | 6.8 | .4 | 0 | 0 |
| Copper-coated iron..... | 0 | 0 | 0 | 0 | .2 | Trace | 0 | 0 |
| Chrome-plated steel.... | 31.1 | 1.8 | 17.9 | 1.1 | 2.6 | .2 | 1.4 | .1 |
| Spring steel..... | 39.5 | 2.3 | 34.2 | 2.0 | 25.8 | 1.5 | 35.9 | 2.3 |
| Heavy iron..... | 214.4 | 12.2 | 255.0 | 14.9 | 122.4 | 7.2 | 153.2 | 9.7 |
| Hardened steel..... | 135.3 | 7.7 | 61.4 | 3.6 | 50.0 | 3.0 | 17.9 | 1.1 |
| Cast iron..... | 146.4 | 8.3 | 115.5 | 6.6 | 113.5 | 6.7 | 104.5 | 6.6 |
| Cast steel..... | 54.0 | 3.1 | 93.4 | 5.5 | 139.8 | 8.2 | 93.8 | 5.9 |
| Stainless steel..... | 13.9 | .8 | 9.7 | .6 | 4.6 | .3 | 4.7 | .3 |
| Minus 1/4 in..... | 0 | 0 | 17.0 | 1.0 | 0 | 0 | 9.0 | .6 |
| Subtotal..... | 1,381.7 | 78.7 | 1,305.0 | 76.2 | 1,286.8 | 75.9 | 1,186.9 | 75.2 |
| Nonferrous: | | | | | | | | |
| Aluminum..... | 52.5 | 3.0 | 38.3 | 2.2 | 76.7 | 4.5 | 69.4 | 4.4 |
| Zinc..... | 2.0 | .1 | 8.0 | .5 | 2.9 | .2 | 2.2 | .1 |
| Lead..... | .9 | .1 | .1 | Trace | Trace | Trace | .5 | Trace |
| Copper and brass..... | 18.7 | 1.0 | 11.7 | .7 | 17.4 | 1.0 | 16.8 | 1.1 |
| Copper (coated wire)... | 5.1 | .3 | 4.7 | .3 | 6.4 | .4 | 5.0 | .3 |
| Subtotal..... | 79.2 | 4.5 | 62.8 | 3.7 | 103.4 | 6.1 | 93.9 | 5.9 |
| Combustibles: | | | | | | | | |
| Plastic (coated wire).. | 3.3 | .2 | 3.1 | .2 | 4.2 | .3 | 3.4 | .2 |
| Polyurethane foam..... | 19.6 | 1.1 | 2.3 | .1 | 22.7 | 1.3 | 1.7 | .1 |
| Vinyl..... | 13.9 | .8 | 6.9 | .4 | 8.8 | .5 | 4.0 | .3 |
| Other plastics..... | 64.8 | 3.7 | 24.2 | 1.4 | 67.0 | 4.0 | 32.7 | 2.1 |
| Rubber..... | 39.5 | 2.3 | 29.2 | 1.7 | 47.7 | 2.8 | 35.2 | 2.2 |
| Carbon..... | .7 | Trace | 0 | 0 | .7 | Trace | 0 | 0 |
| Other combustibles..... | 56.4 | 3.2 | ² 161.4 | 9.4 | 60.0 | 3.5 | ² 133.0 | 8.4 |
| Subtotal..... | 198.2 | 11.3 | 227.1 | 13.2 | 211.1 | 12.4 | 210.0 | 13.3 |
| Noncombustibles: | | | | | | | | |
| Ceramics..... | 3.3 | .1 | 0 | 0 | 4.0 | .2 | .3 | 0 |
| Glass..... | 68.6 | 3.9 | 1.8 | .1 | 57.8 | 3.4 | 2.3 | .2 |
| Asbestos..... | 1.1 | .1 | 0 | 0 | 1.1 | .1 | Trace | Trace |
| Subtotal..... | 73.0 | 4.1 | 1.8 | .1 | 62.9 | 3.7 | 2.6 | .2 |
| Nonmagnetic: | | | | | | | | |
| Minus 1/4 in..... | 0 | 0 | 115.6 | 6.8 | 0 | 0 | 85.7 | 5.4 |
| Fluids..... | 24.3 | 1.4 | ND | ND | 32.0 | 1.9 | ND | ND |
| Total..... | 1,756.4 | 100.0 | 1,712.3 | 100.0 | 1,696.2 | 100.0 | 1,579.1 | 100.0 |

ND Not determined separately--included with steelplate.

¹The weights of the shredded materials are representative of 1 automobile.²Includes the weight of all combustibles from the air classification systems.

TABLE 11. -Metals recovered from shredded Japanese automobiles compared with metals contained in similar dismantled automobiles¹

| Metals | Dismantled metals, lb | Recovered shredded metals, ² lb | Shredded metal recovery versus dismantled content, pct |
|------------------------|-----------------------|--|--|
| Ferrous metals..... | ³ 1,389.1 | 1,293.7 | 93.1 |
| Nonferrous metals: | | | |
| Aluminum..... | 71.1 | 49.4 | 69.5 |
| Zinc..... | 5.3 | 4.1 | 77.4 |
| Lead..... | .5 | .1 | 20.0 |
| Copper and brass..... | 18.8 | 9.6 | 51.1 |
| Copper (coated wire).. | 5.9 | 0 | 0 |
| Subtotal..... | 101.6 | 63.2 | 62.2 |
| Total..... | 1,490.7 | 1,356.9 | 91.0 |

¹The metal weights shown are averages from the combined automobiles.

²Recovered metals are collected in the magnetic and elutriated products. Nonferrous metals in the collected magnetic product and copper from coated wire were not recovered.

³The dismantled automobile weights excluded 79.5 lb and 13.3 lb of ferrous metals from the wheels and gas tanks, which are not shredded.

HIGH-STRENGTH LOW-ALLOY STEEL

HAND DISMANTLING

HSLA steel is contained throughout the "white body"⁵ of the Sentra automobiles and constitutes, by weight of the metals, 33.1 pct of the two-door and 35.8 pct of the four-door sedan. The major portions are used in the doors, hood, and trunk lid, which are accessible for removal.

Structural and support applications throughout the body framework account for the remaining HSLA steel. The difficulty in identifying the HSLA steels and the welded construction of the unibody and

components would deter practical hand recovery methods.

RECYCLING

Meltdown of the magnetic product from one of the shredded Sentras at the Albany Research Center produced a steel with the following analysis (weight percent):

| | |
|------------|------------|
| Al = <0.01 | Ni = 0.064 |
| C = 0.019 | P = 0.033 |
| Cr = 0.013 | S = 0.019 |
| Cu = 0.31 | Si = <0.01 |
| Mn = <0.01 | Sn = <0.01 |
| Mo = <0.01 | V = <0.01 |

⁵A "white body" is a complete body including doors, hood, lid, etc., that is welded and fitted with no accessories. It is everything that is to be painted the color of the automobile.

Addition of quartz and limestone to the furnace to form a suitable slag and FeMn addition to increase the carbon and manganese levels produced a melt having the following analysis (weight percent):

| | |
|------------|------------|
| Al = 0.020 | Ni = 0.072 |
| C = 0.048 | P = 0.041 |
| Cr = 0.017 | S = 0.024 |
| Cu = 0.45 | Si = <0.01 |
| Mn = 0.040 | Sn = 0.01 |
| Mo = <0.01 | V = <0.01 |

After 30 min, the melt was tapped, sampled, and analyzed. The analysis of the final steel product follows (weight percent):

| | |
|------------|------------|
| Al = <0.01 | Ni = 0.075 |
| C = 0.021 | P = 0.037 |
| Cr = 0.018 | S = 0.012 |
| Cu = 0.39 | Si = <0.01 |
| Mo = <0.01 | Sn = <0.01 |
| Mn = <0.01 | V = <0.01 |

The slag analysis (weight percent) was--

| | |
|---------------------------------------|-------------------------|
| Al ₂ O ₃ = 3.82 | Mo = 0.001-0.01 |
| B = 0.01-0.1 | Ni = ND |
| C = ND | P = ND |
| CaO = 10.8 | S = 0.034 |
| Cr = 0.03-0.3 | SiO ₂ = 18.0 |
| Cu = 0.001-0.01 | Sn = ND |
| Fe = 51.0 | Ti = 0.003-0.03 |
| MgO = 0.91 | V = 0.003-0.03 |
| Mn = 0.03-0.3 | (ND = Not detected) |

In all three metal samples, elements not detected by spectrographic qualitative analysis were As, B, Ba, Be, Ca, Cb, Cd, Co, Hf, Mg, Na, Pb, Sb, Ta, Ti, W, Zn, and Zr.

The analysis represents a standard carbon steel that conforms to AISI grade 1005 and shows that a standard steel can be melted directly from this scrap material. Any number of steel compositions can be prepared therefrom with suitable alloy additions.

Spectrographic analyses demonstrated that undesirable tramp elements were not present at levels above our detection limits in any of the metal samples. This indicates that HSLA steel from these automobiles should not adversely affect the quality of ferrous products prepared therefrom.

CONCLUSIONS

The average weight of the four hand-dismantled Japanese automobiles was 1,938.3 lb, including 1,472.9 lb ferrous metals, 115.6 lb nonferrous metals, 275.2 lb combustibles, 72.3 lb noncombustibles, and 2.3 lb electrical components. The respective weight percents were 76.0 pct ferrous metals, 6.0 pct nonferrous metals, 14.2 pct combustibles, 3.7 pct noncombustibles, and 0.1 pct electronic components. Compared to previously dismantled circa 1960 U.S. automobiles, the

four Japanese-manufactured automobiles were smaller and contained a lower percentage of ferrous metals, comparable nonferrous metals, and a higher percentage of nonmetals. More than 60 pct of the ferrous metals were light gage steel, including HSLA steel, and of the 6-pct nonferrous metal content, more than 73 pct was aluminum.

Shredding of the Japanese automobiles, less tires, fluids, tools, wheels,

batteries, and gas tanks, yielded average ferrous metal recoveries of 1,293.7 lb and nonferrous metal recoveries of 63.2 lb per automobile. There was also 223.2 lb of reject materials to be landfilled. This calculated to 99.2 pct ferrous metal recovery based upon total collected products, or 93.9 pct recovery based upon the projected shredder input from dismantling data. The major difference in loss is attributed to material hangups in the shredding mill and transfer equipment, which would be ultimately recovered in continuous operation.

Nonferrous metal recovery from the shredded automobiles was 79 pct. There was an 8.2 pct nonferrous metal loss during magnetic separation which reported with the ferrous product, and 12.8 pct was lost in the combined rejects. The nonferrous metal loss from shredding is

excessive, and continued emphasis on nonferrous metal recovery appears to be warranted. Automobile shredder rejects, presently landfilled, will be of future concern when shredding the smaller automobiles. There will be a one-third increase in the amount of rejects for landfill to maintain the current shredded ferrous scrap production.

The HSLA steels used in the manufacture of the Sentra automobile, which are 12.2 pct of the total ferrous metals content, appear to be amenable to steel and foundry usage in recycling ferrous scrap. Total separation of a HSLA steel product by hand dismantling or from the shredded automobile does not appear to be feasible. No materials used in the manufacture of the Japanese automobiles would pose problems in present recycling technology.

REFERENCES

1. Callahan, J. M., and R. Hartley, Jr. Why Japan's Ahead. Automotive Industries, March 1982, pp. 34-37.
2. Chindgren, C. J., K. Dean, and L. Peterson. Recovery of the Nonferrous Metals From Auto Shredder Rejects by Air Classification. BuMines TPR 31, 1971, 11 pp.
3. Steel, D. K., and J. Sterner. A Water Elutriation System for Recovering Nonmagnetic Metals From Automobile Shredder Rejects. BuMines RI 8771, 1983, 22 pp.
4. Dean, K. C., and J. W. Sterner. Dismantling a Typical Junk Automobile To Produce Quality Scrap. BuMines RI 7350, 1969, 17 pp.